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Genetic variability and character association for yield and quality traits in early maturing Indian cauliflowers

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ABSTRACT

Significant differences were observed among genotypes in early Indian cauliflower suggesting sufficient variability for yield and quality characters. The genotypes DC-98-4, DC-98-10 and DC-124 were found superior with respect to yield and quality characters. The overall values of PCV were higher than those of GCV. The highest estimate of GCV was observed for vitamin C contents (54.58) followed by duration of curd availability (49.04), while highest heritability was recorded for days to 50% curd formation (0.992). High heritability along with high genetic advance as per cent of mean was estimated for curd compactness, net curd weight and vitamin C content. Total yield had significant positive correlation with net curd weight and harvest index. However, yield was negatively correlated with duration of curd availability and days to 50% curd formation. Path coefficient analysis revealed that net curd weight and curd compactness had the highest positive contribution towards the total yield respectively.

Key words: Genetic variability, heritability, correlation, path coefficient analysis, early maturing cauliflower.

INTRODUCTION

Cauliflower (*Brassica oleracea* var. *botrytis* L.) is one of the most widely grown cool season vegetable crops of India. With the evolution of Indian cauliflower, it is now being grown during summer and rainy season also. Yet, there is limitation of improved early maturing varieties/hybrids. The development of an effective improvement programme depends upon the existence of genetic variability and knowledge of genotypic and phenotypic correlation of yield components. Path coefficient analysis is also very useful in formulating breeding strategy to develop elite genotypes through selection in advanced generations. Thus, the nature and magnitude of variability present in the gene pool for different characters and relationship with each other determine the success of genetic improvement of a character. Since the pattern of inheritance of quantitative characters is highly complex, therefore the present investigation was undertaken to study the genetic parameters such as variability, heritability, genetic advance, correlation and path analysis in conjunction to better understand it.

MATERIALS AND METHODS

The present investigation was conducted at the research farm of the Division of Vegetable Science and biochemical analysis was carried out in the laboratories of the Divisions of Vegetable Science and Soil Science and Agricultural Chemistry, IARI, New Delhi, during the rainy and winter seasons. The experimental material comprised of 32 genotypes. There were 16 plants in each plot having 5.76 m^2 area planted at 50 cm distance between and 45 cm with in row in a Randomized Block Design, with three replications. Observations were recorded on five randomly selected competitive plants per replication for each entry on eight quantitative and three quality traits, *viz.*, days to 50% curd formation, stem length (cm), net curd weight (kg), curd compactness, marketable curd weight (kg), harvest index (%), duration of curd availability (days), marketable yield (q/ha), vitamin C (mg/100g), potassium (mg/100g) and sulphur (mg/100g) contents. The data regarding above mentioned characters were averaged and subjected to analysis of variance (Panse and Sukhatme, 10). The genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were calculated as per Burton (3). Heritability (broad sense) and genetic advance as per cent of mean were computed by following the methods of Allard (2) and Johnson *et al.* (6), respectively. Correlation and path coefficient analysis were calculated following Al-Jibouri *et al.* (1), Miller *et al.* (8), and Dewey and Lu (4), respectively.

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RESULTS AND DISCUSSION

The success of breeding programme depends upon quantum of variability present in the available germplasm. Analysis of variance showed the difference due to genotypes was significant for all the characters studied. This indicates sufficient genetic variability to be exploited in a breeding programme and was reflected in the broad range observed for each trait (Table 1). The line DC-98-4 was found to excel others in overall performance with respect to morphological parameters such as stem length, curd compactness,

net curd weight, harvest index and yield (192.7 q/ha). In the quality parameters like vitamin C, potassium and sulphur content, line DC-124 and DC-98-10 were found to be superior for the quality attributes (Table 1). These genotypes can be amply exploited in a quality improvement programme.

The phenotypic and genotypic coefficients of variation (PCV), heritability and genetic advance as percent of mean were worked out to various morphological and quality characters (Table 2). The result showed higher PCV than GCV, which indicated environmental interferance in the manifestation of these characters. This result is in line with Jamwal *et al.* (5). The PCV and GCV were highest for duration of curd availability and vitamin C content. Similar findings were also reported by Pandey and Naik (9), Jamwal *et al.* (5), and Singh *et al.* (13). For selection of such characters, therefore, more vigorous testing of progenies over different environments may be required. Estimates of heritability were high for characters like days to 50% curd formation, stem length and net curd weight. The estimates of heritability were moderate to high for other characters like marketable curd weight, duration of curd availability, potassium and sulphur content. High heritability can be attributed to the greater role of additive gene and additive x additive gene action, which can be exploited by following simple selection. Similar reports have also been put forward by Singh *et al.* (13), and Reddy and Varalakshmi (11). High heritability coupled with high genetic advance were noted for curd compactness, net curd weight and vitamin C content suggesting thereby that these traits could be considered as reliable indices for selection and higher responses of this trait could be expected from selection.

Correlation studies (Table 3) exhibited positive and significant association of yield with net curd weight, marketable curd weight and harvest index. However, yield was negatively correlated with duration of curd availability and days to 50% curd formation indicating that selection for early maturity may have adverse effect on yield. Significant positive correlation was reported by Sharma *et al.* (12). The inter-correlation involving marketable curd weight with yield revealed the relative influence of these characters on the total yield. The significant positive association among these characters suggested further the scope for improvement of these traits. Similar observations have also been recorded by Sharma *et al.* (12), Khar and Pathania (7), and Thakur *et al.* (14). With regard to quality attributes, all the characters showed positive correlation amongst each other. However, it was negative between dry matter and potassium content. Correlation studies give an idea about the positive and negative associations of different characters with yield and also among themselves. However, the nature and extent of contribution of these characters towards yield is not obtained. Hence, path coefficient analysis was used to make partition of the correlation coefficient of the different characters studied to know direct and indirect effects on yield. The information obtained helps in giving proper weightage to the various characters during selection or other breeding programme so that the improvement of desirable traits can be achieved effectively.

Path coefficient analysis (Table 4) indicated the direct and indirect effect of the eleven morphological and biochemical traits on the total yield. The highest direct effect on yield was from net curd weight. Other characters, which indirectly influenced the yield were net curd weight and curd compactness. Therefore, these characters also offer scope for inclusion in the selection programme. The highest negative direct effect was observed for gross plant weight followed by harvest index and dry matter in the early maturity group, and for dry matter, harvest index and days to 50% curd formation in the mid maturity group. These observations suggested the selection of lower values for these traits. The study revealed that the values of residual effect were very less, *i.e.* 0.0399. This indicates that

Table 1. Range and mean values for different characters of 32 genotypes of early maturing Indian cauliflower.

Component	Days to 50% curd formation	Stem length (cm)	Net curd wt. (kg)	Curd compactness	Marketable curd wt. (kg)	Harvest index (%)	Duration of curd availability (days)	Marketable yield (q/ha)	Vitamin C (mg/ 100g)	Potassium (mg/ 100g)	Sulphur (mg/ 100g)
Range	91.24-129.22	4.52-15.13	0.210-0.410	30.40-110.11	0.280-0.490	18.19-48.43	5.37-29.42	114.57-193.10	17.68-103.23	286.67-391.33	12.61-41.48
MSS	49.45**	6.28**	0.115**	2673.27**	0.12**	236.99**	22.81**	1489.42	985.06**	6755.79**	200.30**
Mean	106.69	0.433	0.320	54.91	0.390	33.10	12.04	151.10	46.38	335.69	22.45
$CD_{0.05}$	1.702	0.866	0.028	6.79	0.034	4.06	4.836	12.86	4.522	36.014	5.914

MSS: Mean sum of squares; *, ** Significant at 5 and 1% levels.

Table 2. Mean performance of 32 cauliflower genotypes of early maturity group for different yield and quality characters.

Genotype	Days to 50% curd formation	Stem length (cm)	Curd compact-ness	Marketable curd weight (kg)	Net curd weight (kg)	Harvest index (%)	Duration of curd availability (days)	Marketable yield (q/ha)	Vitamin C (mg/100 g)	Potassium (mg/100 g)	Sulphur (mg/100 g)
DC-1	124.96	12.74	50.89	0.340	0.290	29.63	5.37	124.30	47.34	322.50	22.85
DC-4	129.22	12.80	45.69	0.340	0.290	27.03	7.11	124.20	75.43	343.85	29.79
DC-5	116.16	11.39	88.85	0.390	0.320	41.16	8.51	156.40	18.00	321.75	25.33
DC-6	107.93	10.73	69.23	0.380	0.310	43.36	10.40	141.00	47.91	300.00	34.51
DC-7	124.10	11.22	59.15	0.460	0.400	48.43	13.57	160.40	80.47	365.92	18.01
DC-8	95.30	10.84	69.57	0.400	0.310	32.67	17.70	163.33	91.99	329.17	23.28
DC-9	111.67	8.32	53.01	0.430	0.340	46.01	12.33	154.23	40.07	302.33	22.95
DC-10	101.45	12.24	48.41	0.490	0.400	47.25	17.55	193.10	71.62	378.33	21.15
DC-22	128.27	15.13	40.12	0.400	0.300	36.69	9.40	156.93	18.64	373.33	28.60
DC-33-8	98.81	12.63	46.31	0.470	0.390	37.56	11.52	163.50	18.68	336.50	21.19
DC-84	100.38	12.30	44.46	0.390	0.410	37.15	12.95	163.00	40.02	318.50	20.68
cc-12	111.71	12.68	55.29	0.420	0.300	34.69	10.29	136.77	17.68	338.33	23.37
cc-14	100.80	12.31	71.38	0.380	0.370	39.90	11.87	176.80	21.61	334.17	17.14
cc-15	101.38	7.94	76.92	0.370	0.320	34.20	11.29	135.47	45.70	360.00	22.51
DC-83	95.79	9.15	48.51	0.380	0.310	27.85	8.55	123.63	32.15	340.50	21.20
DC-18	121.15	10.26	77.41	0.380	0.310	32.79	8.19	142.83	35.35	342.33	31.47
23000	95.59	11.38	60.12	0.460	0.310	27.40	14.74	151.33	22.63	349.17	21.09
DC-98-4	98.05	6.13	110.11	0.380	0.380	40.22	16.95	192.77	99.28	355.00	25.26
DC-41-5	101.65	6.68	61.83	0.370	0.210	27.66	7.35	154.63	29.52	303.33	20.02
DC-85	94.37	9.74	46.64	0.440	0.300	30.33	12.63	140.37	42.45	330.00	24.42
DC-98-10	97.97	8.74	37.87	0.440	0.380	30.30	10.69	167.51	103.23	320.00	17.66
DC-112	115.94	5.68	47.73	0.460	0.410	37.24	13.06	182.53	38.07	347.50	14.10
DC-113	91.24	4.52	42.80	0.390	0.320	35.67	29.09	161.67	83.88	335.83	21.53
DC-122	98.54	5.39	30.40	0.370	0.310	27.89	14.46	154.70	24.84	310.83	17.62
DC-124	116.76	6.78	46.10	0.340	0.280	27.18	6.24	142.70	38.66	391.33	41.48
aa(395)	99.30	7.41	39.15	0.350	0.300	22.75	6.37	124.20	24.61	296.67	12.61
PK-3	124.84	6.36	44.84	0.280	0.220	18.19	10.49	119.13	51.67	286.67	16.70
754	96.13	9.67	55.69	0.270	0.210	27.39	22.54	114.57	66.07	375.00	25.18
VV-5-6-2	97.58	4.74	45.16	0.290	0.240	24.07	29.42	115.90	34.77	336.67	17.13
Pusa Deepali	107.74	7.39	62.08	0.410	0.350	24.90	12.26	164.00	66.55	289.17	19.85
Pant Gobhi	108.03	6.89	30.42	0.410	0.370	30.29	11.31	141.43	27.82	379.17	25.65
First Crop Ageti	101.20	5.13	51.10	0.480	0.410	31.33	11.13	191.73	27.30	328.33	14.05
Range	91.24	129.22									
Grand mean	106.69	9.22	54.91	0.390	0.320	33.10	12.04	151.10	46.38	335.69	22.45
CD (P=0.05)	1.702	0.866	6.79	0.034	0.028	4.06	4.836	12.186	4.522	36.014	5.914

the characters chosen for the present study is the main components of yield and that the variability in yield is accounted by the characters chosen for this investigation to a considerable extent. The result indicated the presence of adequate genetic variability with in the germplasm evaluated for

Table 2. Estimates of parameters of variability for yield and quality characters in 32 early maturing Indian cauliflower genotypes.

Character	Heritability (broad sense)	GCV	PCV	GA as % mean
Days to 50% curd formation	0.992	10.57	10.62	21.69
Stem length	0.967	31.37	31.89	63.56
Net curd weight	0.911	17.40	18.22	34.38
Curd compactness	0.942	30.56	31.49	61.12
Marketable curd weight	0.871	13.74	14.72	25.64
Harvest index (%)	0.894	21.84	23.10	42.54
Duration of curd availability	0.799	49.04	54.86	90.28
Marketable yield	0.896	14.47	15.29	28.21
Vitamin C (mg/100 g)	0.988	54.58	54.91	117.77
Potassium (mg/100 g)	0.548	7.23	9.77	11.03
Sulphur (mg/100 g)	0.711	25.31	30.02	41.29

GCV = Genotypic coefficient of variation; PCV = Phenotypic coefficient of variation; GA = Genetic advance

Table 3. Estimates of phenotypic and genotypic correlation among different traits in early maturing Indian cauliflower.

		X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}
X_1	P	0.333	-0.084	-0.014	-0.124	0.071	-0.572	-0.191	-0.097	0.069	0.284
	G	0.336	-0.086	-0.016	-0.130	0.079	-0.629	-0.197	-0.100	0.090	0.356
X_2	P		0.119	0.098	0.150	0.355	-0.273	-0.025	-0.116	0.150	0.257
	G		0.116	0.095	0.153	0.385	-0.298	-0.037	-0.118	0.221	0.309
X_3	P			0.084	0.908**	0.609**	-0.172	0.763**	0.141	0.131	-0.194
	G			0.040	0.932	0.617	-0.196	0.768	0.147	0.189	-0.271
X_4	P				0.158	0.353*	-0.009	0.28	0.191	0.011	0.200
	G				0.117	0.363	-0.006	0.254	0.198	0.001	0.226
X_5	P					0.666**	-0.161	0.876**	0.109	0.105	-0.174
	G					0.696	-0.217	0.872	0.112	0.118	-0.249
X_6	P						-0.049	0.568**	0.124	0.210	0.120
	G						-0.077	0.587	0.129	0.275	0.126
X_7	P							0.007	0.255	0.057	-0.077
	G							-0.013	0.291	0.097	-0.107
X_8	P								0.211	0.105	-0.24
	G								0.202	0.086	-0.178
X_9	P									0.062	0.038
	G									0.082	0.038
X_{10}	P										0.369*
	G										0.423

*,**Significant at 5 and 1% levels; X_1 = Days to 50% curd formation; X_2 = Stem length (cm); X_3 = Net curd weight (kg); X_4 = Curd compactness; X_5 = Marketable curd weight (kg); X_6 = Harvest index (%); X_7 = Duration of curd availability (days); X_8 = Marketable yield (q/ha); X_9 = vitamin C (mg/100 g); X_{10} = potassium (mg/100 g); X_{11} = sulphur (mg/100 g).

Table 4. Estimates of direct and indirect effect of different characters on marketable yield at phenotypic and genotypic levels in early maturing Indian cauliflower.

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	Corr. with yield (q/ha)
X_1	-0.184	0.371*	-0.598	0.014	0.087	-0.492	0.549**	-0.080	-0.071	-0.195	-0.197
X_2	-0.062	1.106**	0.806**	-0.080	-0.103	-2.388	0.260	-0.094	-0.173	-0.169	-0.037
X_3	0.016	0.128	6.944**	-0.033	-0.624	-3.821	0.171	0.117	-0.148	0.149	0.768**
X_4	0.003	0.105	0.275	-0.846	0.079	2.247**	0.005	0.158	-0.001	-0.124	0.254
X_5	0.024	0.169	6.471**	-0.099	-0.669	-4.312	0.190	0.089	-0.092	0.136	0.872**
X_6	-0.015	0.426*	4.283**	-0.307	-0.466	-6.195	0.067	0.103	-0.215	-0.069	0.587**
X_7	0.116	-0.329	-1.361	0.005	0.145	0.478**	-0.873	0.232	-0.076	0.059	-0.013
X_8	0.018	-0.131	1.023**	-0.167	0.075	-0.797	-0.254	0.797**	-0.064	-0.021	0.211
X_9	-0.017	0.244	1.312**	-0.001	-0.079	-1.701	-0.084	0.065	-0.783	-0.231	0.105
X_{10}	-0.065	0.342*	-1.884	-0.191	0.167	-0.779	0.094	0.031	-0.331	-0.548	-0.240

Residual effect = 0.0399; *, ** Significant at 5 and 1% levels, X_1 = Days to 50% curd formation; X_2 = Stem length (cm); X_3 = Net curd weight (kg); X_4 = Curd compactness; X_5 = Marketable curd weight (kg); X_6 = Harvest index (%); X_7 = Duration of curd availability (days); X_8 = vitamin C (mg/100 g); X_9 = potassium (mg/100 g); X_{10} = sulphur (mg/100 g).

the improvement of quantitative and quality traits. Correlation and path coefficient studies suggested that the selection should be primarily based on the component characters which exhibited significant positive correlations with yield and also had either direct or indirect effect on yield. This may lead to development of high yielding genotypes in the early maturity groups of cauliflower.

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